Simulated Galactic Cosmic Radiation Exposure Impairs Mouse Vertebral Bone Adaptations to Exercise During Recovery from Partial Weightbearing

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Category: Undergraduate

ABSTRACT

Partial weightbearing that simulates Lunar gravity (1/6th of Earth's gravitational force) results in a loss of bone volume. High energy radiation like that found in galactic cosmic radiation exposure also negatively affects the skeleton. Because resistance training is the most effective exercise mode to counteract disuse-induced bone loss, this experiment combined low-dose, high-energy simulated galactic cosmic radiation (GCR) exposure, followed by a period of partial weightbearing (PWB), and then a period of resistance exercise or normal cage activity during recovery. Young adult female BALB/c mice were randomly assigned to age-matched cage controls (CC) or PWB (G/6) groups. From there, animals were further divided into 0.5 Gy ^{36}Fe radiation exposure (RAD) or sham exposure (SHAM) groups. Radiation exposure was performed at NASA's Space Radiation Laboratory at Brookhaven National Laboratory before shipping to Texas A&M. GCR was followed by a 21-day period of PWB, equivalent to being placed in a simulated lunar gravity environment. A 21-day recovery period began on Day 22, during which PWB animals were assigned to one of two groups: recovery with normal cage activity (G/6 + Rec) or resistance training during recovery (G/6 + RecEX). The latter group was trained three times every four days with a tower climbing training regimen, climbing a 1-meter wire mesh tower at an 85° angle. This training was repeated for a total of 15 climb sessions. As the exercise period progressed, weights were taped on to the mice tails. *Ex vivo* micro-computed tomography (µCT) scans were performed by Matthew Allen, PhD at the Indiana University School of Medicine to quantify cancellous bone microarchitecture in the 4th lumbar vertebral body. Means for cancellous bone volume (%BV/TV), trabecular thickness (Tb.Th), and trabecular number (Tb.N) from Day 42 of the experiment were compared to Day 21 means by 2-way ANOVA to determine the changes occurring through the recovery period. RecEX had no significant affect on ΔBV/TV or ΔTb.Th, but ΔBV/TV and ΔTb.Th were significantly lower in RAD groups than in SHAM groups ($p<0.001$). ΔTb.N was significantly higher in exercised groups than non-exercised groups ($p<0.05$), but no significant differences in ΔTb.N were shown between RAD and SHAM groups. These data suggest that GCR exposure diminishes the ability of bone to respond to exercise during recovery form a period of reduced weightbearing.